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INTRODUCTION

Polio is a faecal-orally transmitted, highly infectious disease caused by wild-type polio virus (WPV) types 1, 2 or 3.^{1 2} Today, the majority of polio outbreaks are caused by circulating vaccine-derived polio viruses (cVDPV) originating from back-mutations of oral polio vaccine (OPV) viruses which have recovered the WPV phenotype properties of neurovirulence and transmissibility; most cVDPV originate from type 2 OPV.^{3–5} Type 2 WPV has been eradicated already since 1999 and type 3 WPV has no longer been detected since November 2012.⁶ Thus, the major challenges now are posed by remaining WPV type 1 and by cVDPV.⁷

EARLY, BUT TRUNCATED SUCCESS

In 1988—8 years after the successful eradication of smallpox—the Global Polio Eradication Initiative (GPEI) was established as a public-private partnership with the goal to eradicate polio by the year 2000. Back then, the annual global number of polio cases was around 350 000 and the disease was endemic in 125 countries.⁶ The main interventions of the GPEI were to increase OPV coverage—later replaced by inactivated polio vaccine (IPV) in industrialised countries—through the routine Expanded Program on Immunization (EPI) of the WHO, and mass vaccination campaigns.⁶ Subsequent modelling studies indicated that polio eradication, as compared with control, would be more cost-effective and ultimately incur substantial net benefits.^{8 9} These studies were, however, criticised as depending on untenable or at least highly optimistic assumptions.^{10–12}

The initial results of the GPEI were impressive, with a rapid reduction in the numbers of global polio cases and endemic countries. Eradication, however, was neither achieved by the year 2000, nor were new deadlines met in the following years.^{4 6 13} Since 2012, the

Summary box

- The Global Polio Eradication Initiative was established in 1988 when polio was endemic in 125 countries causing some 350 000 clinical cases per year. Today, the number of polio cases has been reduced by 99.9% and polio remains endemic in only three countries—Pakistan, Afghanistan and possibly Nigeria.
- This is a great success of the global community. However, after a number of missed deadlines and investments of US\$20 billion, the eradication goal has still not been achieved. The challenges of the ‘last mile’ of eradication seem insurmountable. They comprise political instability and community resistance on one hand.
- On the other hand, secondary epidemics abide, initially due to wild-type polio virus imported from endemic countries and now due to circulating vaccine-derived polio viruses. The latter epidemics originate from back-mutations of oral polio vaccine (OPV) viruses regaining neurovirulence under conditions of low immunisation coverage and weak health systems.
- Finally, the challenges of the global transition from OPV to inactivated polio vaccine, of destroying all OPV stocks, of controlling polio spread from long-term excretors, and of preventing deliberate spread of de-novo synthesised polioviruses have to be overcome. Under all likely scenarios, polio vaccination will need to be continued for decades, or indefinitely.
- We argue that the global community should celebrate the massive reduction in polio cases, and then shift course from polio eradication to a more realistic goal of sustained, systematic control, along with increased investments into routine vaccine delivery systems within the frame of Universal Health Coverage.

World Health Assembly considered polio a ‘Programmatic Emergency for Global Public Health’,^{14 15} and in May 2013 it endorsed the Polio Eradication & Endgame Strategic Plan 2013–2018 (the ‘Polio Plan’), which calls for the eradication of all WPV, all cVDPV and all OPV viruses.^{6 14} The Polio Plan combined locally adapted new tactics to strengthen

national programme with technological innovations (eg, more effective and safer monovalent and bivalent OPV formulations) to achieve its main objectives, namely to stop all WPV transmission by the year 2014 and to speed up the control of cVDPV outbreaks.¹⁴

WPV transmission, however, stopped neither in 2014 (as planned) nor in 2018 (the year planned for certification). In January 2019, the Chairs of GPEI's main global advisory bodies issued a joint statement 'urging all involved in the effort to excel in their roles'.⁷ While their goal to reach 'every last child' with vaccines including polio remains highly commendable, the goal of eradication warrants reconsideration. Unlike smallpox, polio lacks ideal characteristics for eradication. Smallpox had a very high manifestation rate and a straightforward epidemiological case definition, making outbreaks easy to identify; and a vaccine with the characteristics of a near perfect intervention tool (eg, heat stable; long-term immunity, potentially life-long, after one inoculation). This made eradication possible within slightly more than a decade between the onset of the programme in 1966 and the last naturally occurring case in 1977—and with a rather small budget.

But none of these apply to polio: several doses of OPV are needed to convey immunity in low-hygiene settings; and the virus may have been spreading for some time before clinical cases are diagnosed.¹⁶ Moreover, the problem of cVDPV has only been realised in the year 2000 when it was first detected on Hispaniola.¹⁷ In addition, suspicions towards polio vaccination among Muslim populations in the remaining endemic areas has increased since the Afghanistan war started in 2002.^{12 18}

CHALLENGING EPIDEMIOLOGICAL DEVELOPMENTS

Since 2000, secondary epidemics—caused by either a direct spread of WPV from the remaining endemic countries to neighbouring countries (although no longer in the past 5 years) or by cVDPV—were reported from about 30 countries formerly certified as polio-free, most recently from the Democratic Republic of Congo (DRC), Papua New Guinea, Somalia and Syria.^{4 13 18 19} A total of 21 and 12 WPV cases were reported from Afghanistan and Pakistan, respectively, in 2018; by 26 June 2019, the number of new WPV cases reported had reached already 37 (10 in Afghanistan, 27 in Pakistan).⁴ Thus, polio remains endemic in Afghanistan and Pakistan, two countries which share a porous border. Nigeria, while not certified as polio-free, has so far reported no new WPV cases in 2019.⁴ Regarding cVDPV cases, a total of 104 were reported for the whole of 2018 (DRC 20, Indonesia 1, Mozambique 1, Niger 10, Nigeria 34, Papua New Guinea 26, Somalia 12); by 26 June 2019, the total of number of new cVDPV stood at 20 (Angola 1, DRC 5, Ethiopia 1, Niger 1, Nigeria 9, Somalia 3).⁴

Important reasons for continuing transmission are first, the weak health systems and correspondingly low routine childhood immunisation coverage in many countries still

at risk of polio due to ongoing political instability, underdevelopment and poverty, compounded by the technical challenges of the GPEI; and second, the perception that polio eradication is a priority of wealthier 'Western' countries, not of the people living in the countries where elimination proves to be the hardest, as has been shown in Pakistan.^{20 21} While there have been repeated OPV campaigns in the remaining endemic countries for many years (eg, 6–8 campaigns per year in the critical provinces of Pakistan and Nigeria), routine health services including immunisation services had in the past been largely neglected, even disrupted by vertical polio campaigns,²² and overall vaccination coverage remains low in several countries and regions.²³

The current DRC epidemic has emerged in different provinces as independent cVDPV type 2 outbreaks, which now threatens to spread to other neighbouring countries and may endanger the whole of sub-Saharan Africa (SSA).^{3 5} By 2016, 155 countries had already replaced trivalent OPV with a bivalent (types 1 and 3) vaccine; the DRC outbreak thus demonstrates the weaknesses in polio surveillance systems and—if not contained—may cause a general move back to the trivalent OPV.^{3 4 10 24}

The GPEI faces further technical challenges which incur at least a theoretical risk of future outbreaks. They include the decades-long excretion of polio-related viruses in persons with a B-cell defect (this risk may only be minute as no resulting outbreaks have been identified since the switch from trivalent OPV), the risk of ongoing circulation of polio viruses in populations with high IPV coverage due to low mucosal immunity, the possibility of an accidental spread of unknowingly stored polioviruses from laboratories, or even a deliberate spread of de-novo synthesised polioviruses.^{6 25} Failure to contain poliovirus would be a greater risk than with smallpox virus because resulting outbreaks are less easily identified and thus contained.

And sadly, even successful eradication of poliovirus may not mean an end of polio-like illness. Other viruses from the same family (eg, enteroviruses D68, D71) may produce flaccid paralysis resembling poliomyelitis, with outbreaks reported from a number of industrialised countries in recent years.^{26 27} The existence of other causes of disease does not mean that eradication of one cause should not be attempted. However, it would bring about the challenge of explaining to the world community why outbreaks presenting with the clinical symptoms of a disease eradicated at substantial cost continue to occur.

THE COSTS OF ERADICATION

The cost of the GPEI amounts to around US\$20 billion since its initiation. The Polio Plan included total direct costs of US\$5.5 billion, which were increased to US\$7 billion until 2019.⁵ WHO is currently developing a new strategic plan for the years 2019–2023, with a budget of roughly US\$4.2 billion.⁹ Evidently, a high investment

into a successful eradication programme would be cost-effective, given the long term costs of continuous control programmes⁹; however, this would imply that eradication is technically and politically achievable, which appears increasingly unlikely.^{5 20 28} Thirty years after the onset of GPEI, it remains unclear for how long the international community will be willing to continue funding polio eradication efforts. Furthermore, countries in the developing world may no longer accept the relative neglect of other health sector priorities for the sake of a global programme that fails to keep its promise.¹⁸

The focus on the eradication effort and its repeating failures is tragic: it obscures that the *control* of polio has been a historic success of the global health community. In this respect, the GPEI has made a positive contribution. The original GPEI plan included routine immunisation as one of the four pillars of eradication. After initial, purely vertical efforts which harmed existing EPIs, the polio eradication initiative aimed to strengthen also horizontal, routine immunisation programmes, and in some cases even to support weak health services.^{22 29 30} The EPI brought about major achievements since its initiation in 1974, when immunisation services reached less than 5% of children in developing countries.³¹ By 2014, the mean global coverage of children under 1 year of age with three doses of DTP vaccine (DTP3) was estimated at 85%.³² However, major inequalities remain between and even within countries, with DTP3 coverage rates well below 50% in numerous second-level administrative units of SSA.^{23 32} Hence, further targeted strengthening of the EPI is needed.

FROM ERADICATION TO CONTROL

In 2019, the world 'is at a critical point in polio eradication'.³³ This could be the year to implement the lessons learnt from GPEI and to move from the eradication goal to sustained polio control, as had already been proposed by leading experts on smallpox eradication more than 10 years ago.²⁸ It will not be possible to simply stop GPEI interventions, as the low EPI coverage in a number of developing countries would rapidly lead to polio outbreaks, with the risk of re-established polio endemicity.

Thus, a broad multidisciplinary discussion of all stakeholders and a careful planning is required to establish an alternative WHO-led global Polio Control Programme (PCP). WHO would define minimum immunisation coverage rates to be achieved in all strata of society in all countries as well as intervention measures such as targeted mass vaccination campaigns in case of outbreaks. The phasing out of OPV in exchange to IPV would continue, but monovalent, bivalent and trivalent OPV would be stored and employed to fight outbreaks of symptomatic or asymptomatic (eg, detected through environmental surveillance) polio. A well-designed PCP would thus build on the experiences and some elements

of the GPEI, secure the achievements made, but drop the presently unattainable goal of eradication.

The activities of a PCP would be less demanding and thus less costly compared with the ongoing massive efforts of the already excessively long 'last mile' of the GPEI, assuming an underlying law of diminishing returns. With the shift to PCP, a proportion of GPEI funds could be reinvested into strengthening EPI in countries with low vaccination coverage (this would build on the GPEI goal of transitioning GPEI resources from polio eradication activities to sustaining polio essential functions while addressing other public health priorities). More broadly, as agreed already with the establishment of the sustainable development goals, the global health community would prioritise establishing Universal Health Coverage and committing adequate resources to maintain the gains in healthcare staff and services so far funded via the GPEI.³⁰

CONCLUSION

In conclusion, there are two strategies that the world should not be content with: first, unsystematic and uncoordinated polio control efforts, implemented by individual countries acting on their own. Second, continued polio eradication efforts offering simply more of the same. Urging 'all involved in the effort to excel in their roles' to achieve polio eradication is just such a strategy.⁷ It merely pours more money into an ultimately unsustainable vertical programme.

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